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E46 Traction Control Systems

Model: **E46 DSC III All versions including:**
Teves MK20 99-00 E46 323, 328i,is,iC
Teves MK20 00- Present M3
Teves MK 60 01 - Present 325, 330 i, is, IC and E36/7
Bosch DSC III 5.7 01- Present 330Xi, 325Xi

Production: All E46 from 1999

Objectives:

After completion of this module you will be able to:

- Understand the Operation of DSC III Mk20 EI
- Locate DSC III Components

E46 Dynamic Stability Control

Purpose Of System

The DSC III system is being introduced as an option for the E46 beginning with Model Year 1999 production. Since the introduction of the E46, there have been some changes to the DSC III systems. Depending upon year and model, the following DSC system were used:

- **Teves MK 20** - All 99 and 00 323 and 328 (including is and IC) and the M3.
- **Teves MK 60** - Used from 01 production until present. (not used on iX and M3)
- **Bosch 5.7** - only used on the iX models (325Xi and 330Xi)

These system are all similar in functional operation and basic components. The following training material is designed to help differentiate between the various systems by outlining components and functional operation.

Teves DSC III MK 20

The Teves MK 20 DSC system is based on the Teves MK 20 ASC system used on the 99 E46. The system incorporates all of the features of the previous Teves slip control system and adds the lateral dynamic control of the DSC III system already installed on the E38/E39s. This system uses mostly the same components as the previous DSC systems.

The Teves DSC system is designed to maintain the lateral locating forces for following:

- ABS braking control
- ASC +T traction control
- DSC - Dynamic Stability Control for oversteer and under steer conditions

Teves DSC III MK 60

DSC III MK60 is supplied by Continental Teves and supersedes the Teves DSC III MK20 EI system. The MK60 includes all of the features of the previous MK20 EI system and incorporates two additional functions:

- DBC function
- Modified ADB function

The most important changes from the MK20 EI are:

- Reduction in size of the control unit/hydraulic Unit.
- Installation of the hydraulic unit close to the master cylinder.
- Elimination of a pre-charge pump.
- Magneto resistive wheel speed sensors.

The Teves MK60 system is designed to maintain the vehicles stability during:

- ABS braking regulation
- ASC+T traction control
- DSC for oversteer and understeer control

Additional features are also programmed into the control module to enhance driver safety and comfort. These features are:

- **CBC** Corner Brake Control
- **EBV** Electronic Brake Proportioning
- **MSR** Engine Drag Torque Regulation
- **ADB** Automatic Differential Brake
- **DBS** Dynamic Brake System

Bosch DSC III 5.7

The Bosch DSC III 5.7 is used in the E46/16 in place of the DSC III MK 60 used on 2wd vehicles. The DSC system is the same as used in the E53. HDC is not a feature on 2001 Xi models.

Functions that are specific for the All-Wheel Drive system are:

- Modified ABS function.
- ASC+T (All-Wheel Drive version).
- Four wheel ADB function.

The Bosch DSC III 5.7 system is designed to maintain the vehicle's stability during:

- ABS braking regulation
- ASC+T traction control
- DSC for oversteer and understeer control

Additional features are also programmed into the control module to enhance driver safety and comfort. These features are:

- **CBC** Corner Brake Control
- **EBV** Electronic Brake Proportioning
- **MSR** Engine Drag Torque Reduction
- **DBS** Dynamic Brake System

2002 Model Year Update

The DSC system Mk60 has been further developed with regard to certain functions.
The yaw-rate sensor and the transversal-acceleration sensor will be one component and will be called the sensor cluster. The sensor cluster is installed in the same position as the yaw rate sensor. It is operated at 5 volts and has a separate CAN connection to the control unit.

The ADB function is further improved in DSC by Dynamic Traction Control (DTC). The differential effect is brought about here by active brake intervention and DSC monitoring. The yaw moment is taken into consideration which eliminates the danger of the car swerving as it corners. The DTC is activated by pressing the DSC button. The active DTC system is indicated by the DSC warning light in the instrument cluster.

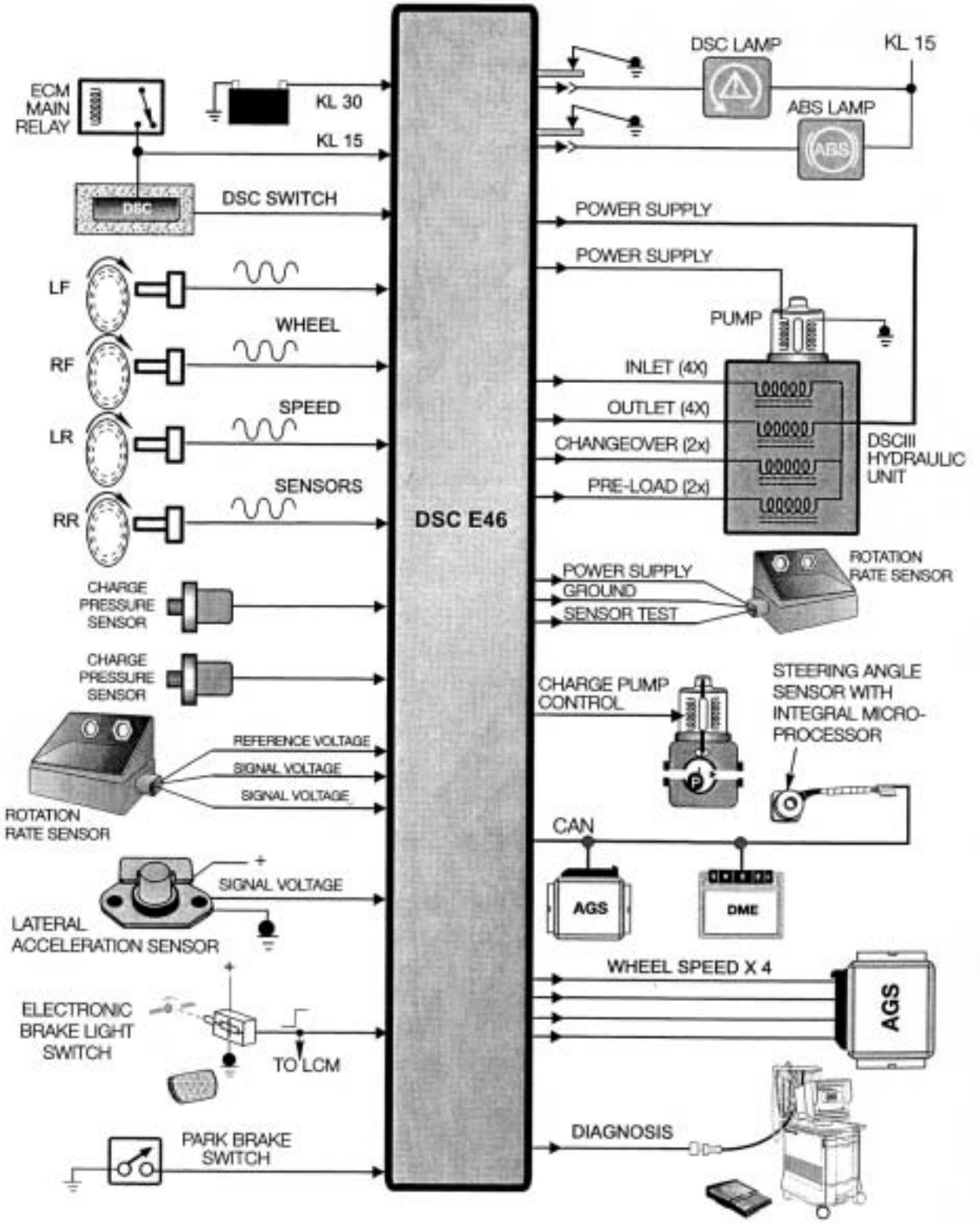
Starting September 1, 2001 DTC will be combined with overrun differential control (SDR). In the event of engine drag-torque control (MSR) while the car is cornering and oversteering, SDR performs a brake intervention at the driving wheel furthest from the bend. The brake intervention at the rear axle does not require any countersteering by the driver, thereby increasing driving safety.

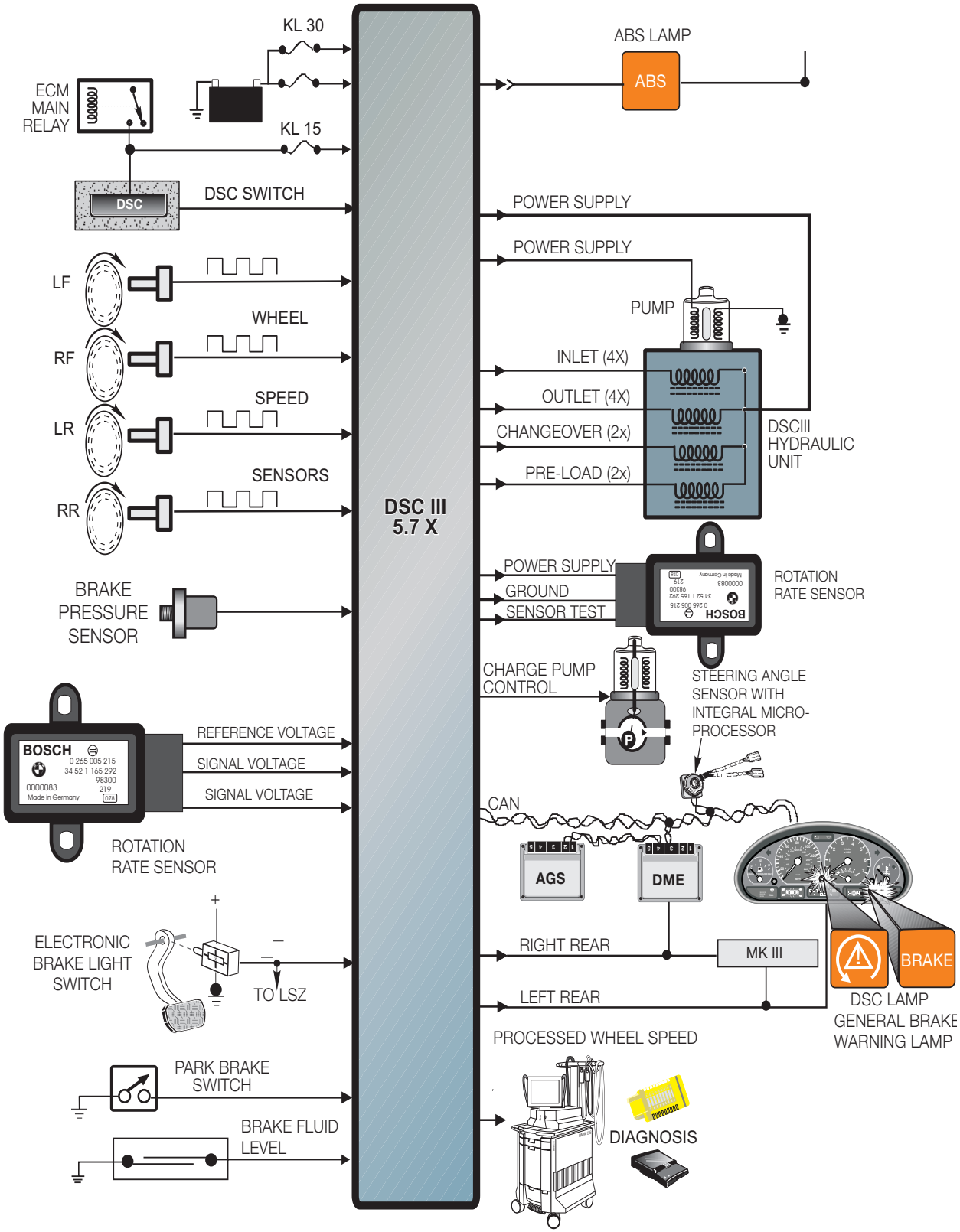
In the event of a total ABS/ASC/DSC malfunction, this will be indicated not only by the established warning lamps but also by the acoustic transmitter in the instrument cluster

Traction and Stability Control Systems Application Chart

Model Year	E36	E36/7 Z3 Roadster/ Coupe	E46	E39	E38	E53	E52	E65 E66	E85
1998	ASC+T	ASC +T MK IV G	N/A	9/97 ASC +T5 S: 528i DSC III 5.3 S: 540i N/A 528i	9/97 DSC III Bosch 5.3 S: 740i/iL S: 750iL	N/A	N/A	N/A	N/A
1999	ASC + T MK IV G 328iC 318ti	ASC + T MK 20 EI (Except M) ASC + T Mk IV G (M Versions)	ASC Teves MK 20 EI	9/98 ASC + T5 S: 528i Bosch DSC III 5.7 S: 540i O: 528i	3/98 Bosch DSC III 5.7 S: 740i/iL S: 750iL	N/A	N/A	N/A	N/A
2000	N/A	from 4/99 Teves MK 20 DSC III	DSC III Teves MK 20 EI from 6/99	6/99 Bosch DSC III 5.7 STD All	3/99 Bosch DSC III 5.7 STD All	DSC III Bosch 5.7 9/99	DSC III Bosch 5.7 1/00	N/A	N/A
2001	N/A	From 9/00 Teves MK 60 DSC III M Versions Teves MK 20 DSC III	DSC III Teves MK 60 from 9/00 M3 Teves MK 20 E46/16 AWD Bosch DSC III 5.7	DSC III Bosch 5.7	DSC III Bosch 5.7	DSC III Bosch 5.7	DSC III Bosch 5.7	N/A	N/A
2002	N/A		Same as 2001	DSC III Bosch 5.7	N/A	DSC III Bosch 5.7		DSC III Bosch 5.7	N/A
2003	N/A	N/A	Same as 2001	DSC III Bosch 5.7	N/A	DSC III Bosch 5.7	DSC III Bosch 5.7	DSC III Bosch 5.7	DSC III Teves MK60

S = STANDARD EQUIPMENT
O = OPTIONAL EQUIPMENT
STD All = Standard All Models


ECM
MAIN
RELAY
KL 30
KL 15
DSC
DSC SWITCH
LF
RF
LR
RR
WHEEL
SPEED
SENSORS
CHARGE
PRESSURE
SENSOR
CHARGE
PRESSURE
SENSOR
REFERENCE VOLTAGE
SIGNAL VOLTAGE
SIGNAL VOLTAGE
ROTATION
RATE SENSOR
SIGNAL VOLTAGE
LATERAL
ACCELERATION SENSOR
ELECTRONIC
BRAKE LIGHT
SWITCH
TO LCM
PARK BRAKE
SWITCH
DSC E46
DSC LAMP
KL 15
ABS LAMP
ABS
POWER SUPPLY
POWER SUPPLY
PUMP
INLET (4X)
OUTLET (4X)
CHANGEOVER (2x)
PRE-LOAD (2x)
DSCIII
HYDRAULIC
UNIT
POWER SUPPLY
GROUND
SENSOR TEST
ROTATION
RATE SENSOR
CHARGE PUMP
CONTROL
STEERING ANGLE
SENSOR WITH
INTEGRAL MICRO-
PROCESSOR
CAN
AGS
DME
WHEEL SPEED X 4
AGS
DIAGNOSIS


KL 30
ABS LAMP
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DSC
DSC SWITCH
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OUTLET (4X)
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CHANGEOVER (2x)
DSCIII
HYDRAULIC
UNIT
SENSORS
PRE-LOAD (2x)
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DSC III
5.7 X
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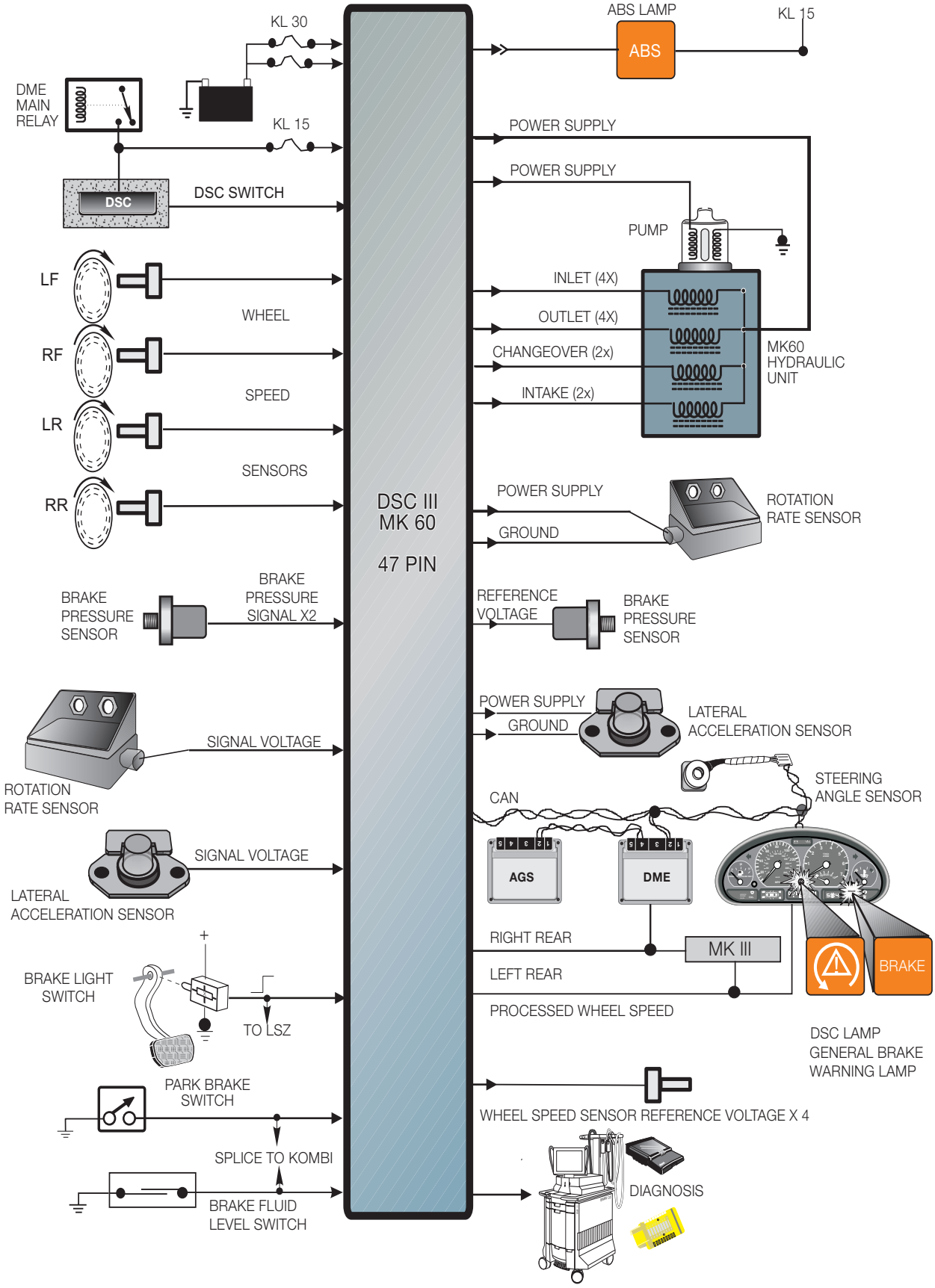
ROTATION
RATE SENSOR
BRAKE
PRESSURE
SENSOR
GROUND
SENSOR TEST
CHARGE PUMP
CONTROL
STEERING ANGLE
SENSOR WITH
INTEGRAL MICRO-
PROCESSOR
REFERENCE VOLTAGE
SIGNAL VOLTAGE
SIGNAL VOLTAGE
CAN
ROTATION
RATE SENSOR
AGS
DME
ELECTRONIC
BRAKE LIGHT
SWITCH
TO LSZ
RIGHT REAR
MK III
BRAKE
LEFT REAR
DSC LAMP
GENERAL BRAKE
WARNING LAMP
PROCESSED WHEEL SPEED
PARK BRAKE
SWITCH
BRAKE FLUID
LEVEL
DIAGNOSIS


KL 30
ABS LAMP
KL 15
ABS
DME
MAIN
RELAY
KL 15
POWER SUPPLY
POWER SUPPLY
DSC
DSC SWITCH
PUMP
LF
INLET (4X)
WHEEL
OUTLET (4X)
RF
CHANGEOVER (2x)
MK60
HYDRAULIC
UNIT
SPEED
INTAKE (2x)
LR
SENSORS
RR
DSC III
MK 60
47 PIN
POWER SUPPLY
ROTATION
RATE SENSOR
GROUND
BRAKE
PRESSURE
SIGNAL X2
BRAKE
PRESSURE
SENSOR
REFERENCE
VOLTAGE
BRAKE
PRESSURE
SENSOR
POWER SUPPLY
LATERAL
ACCELERATION SENSOR
SIGNAL VOLTAGE
GROUND
STEERING
ANGLE SENSOR
ROTATION
RATE SENSOR
CAN
AGS
DME
SIGNAL VOLTAGE
LATERAL
ACCELERATION SENSOR
RIGHT REAR
MK III
BRAKE
BRAKE LIGHT
SWITCH
LEFT REAR
TO LSZ
PROCESSED WHEEL SPEED
DSC LAMP
GENERAL BRAKE
WARNING LAMP
PARK BRAKE
SWITCH
WHEEL SPEED SENSOR REFERENCE VOLTAGE X 4
SPLICE TO KOMBI
DIAGNOSIS
BRAKE FLUID
LEVEL SWITCH

System Components

The E46 DSC III system consists of the following components:

- Integrated Control unit/Hydraulic unit with CAN Interface
- Charge pump (Not used on MK 60)
- Tandem Brake Master Cylinder
- Four wheel speed sensors (Inductive, Hall Effect or Magneto-Resistive)
- Steering Angle Sensor
- Yaw Rate Sensor
- Lateral Acceleration Sensor
- Integrated Rotation Rate/Lateral Acceleration Sensor
- Brake Pressure Sensors (2 on Teves, 1 one Bosch)
- Brake Fluid Level Switch and Expansion Tank
- Brake Light Switch
- Hand Brake Switch
- DSC Button
- DSC Warning Indicator
- CAN Interface (DME/AGS)

Components

Control Module/Hydraulic Unit

The control module is installed in the engine compartment on the right side next to the strut tower.

Either the control module or the hydraulic unit are replaceable as separate components.

All processing functions for ABS/ASC or DSC regulating functions are carried out in the one control module. The module is linked to the CAN bus for communication with the DME and AGS control modules. Additionally the CAN bus is used for communication with the steering angle sensor and for illumination of the ABS and DSC indicator lamps in the instrument cluster.

Teves MK 20
Control Module/Hydraulic Unit

The hydraulic unit consists of the following:

- Four inlet solenoids
- Four outlet solenoids
- Two changeover solenoids
- Two charge solenoids

Control Unit/Hydraulic Unit (MK 60)

The MK60 control unit/hydraulic unit is located in the engine compartment on the left side under the brake master cylinder.

Both the control unit and the hydraulic unit are replaceable as separate components.

The pre-charge pump used on previous systems is no longer required. Rapid pressure build up is possible because of the close proximity of the hydraulic unit to the master cylinder and improvements in the design of the return pump.

The control unit/hydraulic unit itself is 20% smaller and lighter than the previous MK20 EI.

Teves MK 60
Control Module/Hydraulic Unit

All processing functions for ABS, ASC or DSC are performed by the combined control unit/hydraulic unit. The MK 60 control unit is also responsible for processing the wheel speed signals and providing them to other control units.

The MK60 control unit for MY 2002 incorporates the RDW function into its scope of control, making a separate RDW control unit unnecessary. The operating principle continues to be based on the analysis of wheel speed.

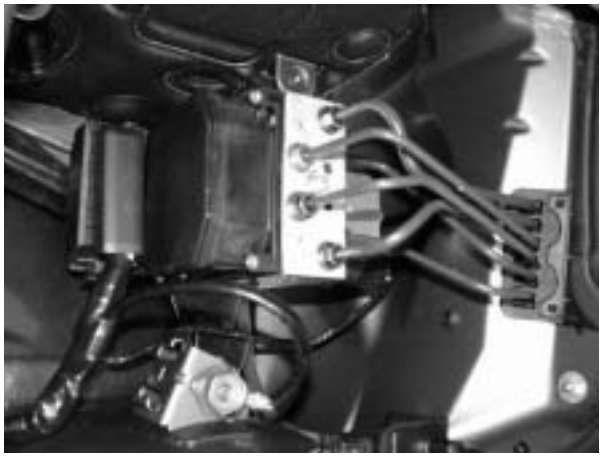
Teves MK 60
Control Module/Hydraulic Unit

Control Unit/Hydraulic Unit (Bosch 5.7)

The Bosch DSC III 5.7 control unit/hydraulic unit is located inside the engine compartment on the right hand side.

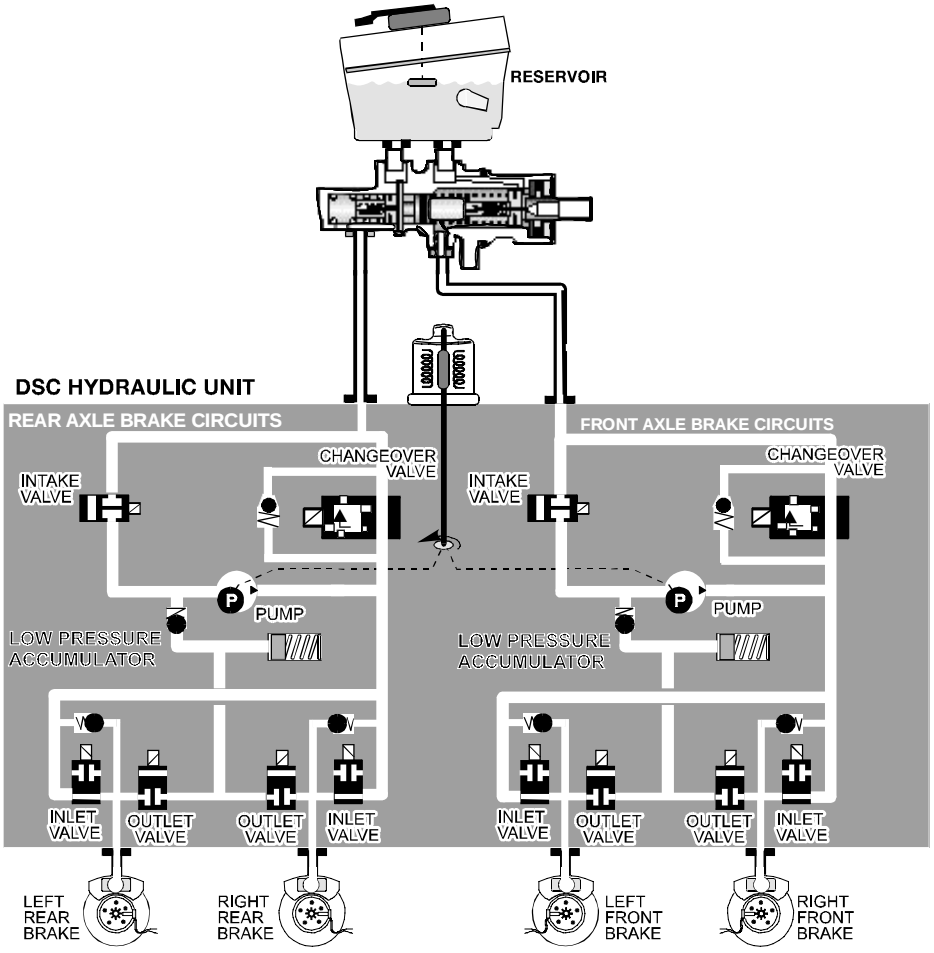
Both the control unit and the hydraulic unit are replaceable as separate components.

All processing functions for ABS, ASC and DSC are performed in the combined control/hydraulic unit. The control unit is also responsible for processing the wheel speed signals and providing them to other control units.



Bosch 5.7
Control Module/Hydraulic Unit

DSC III Hydraulic Unit (Typical)



The hydraulic unit consists of an aluminum block containing 12 solenoid valves, 2 pressure accumulators and the return pump.

- 4 inlet solenoid valves (N/O)
- 2 changeover solenoid valves (N/O)
- 4 outlet solenoid valves (N/C)
- 2 Intake solenoid valves (N/C)

The solenoid valving ensures that normal braking is possible in the event of a defective control unit.

In ABS regulation the pump returns fluid back to the master cylinder circuits. In ASC/DSC regulation with brake intervention, the pump is responsible for building up the brake pressure required for the front and rear hydraulic circuits.

Note: N/O= Normally Open N/C= Normally Closed

Charge Pump (Teves MK 20)

the charge pump is installed between the master cylinder and the brake fluid reservoir. During DSC controlled regulations that involve brake intervention, the charge pump ensures that the required volume of fluid is available for the hydraulic unit.

When activated, the charge pump draws fluid from the reservoir and delivers it to the master cylinder at a pressure of 10 Bar.

Pre-Charge Pump (Bosch 5.7)

The pre-charge pump is located below the master cylinder in the left side of the engine compartment.

During ASC or DSC regulation with brake intervention, the DSC control unit activates the pre-charge pump. The pump delivers brake fluid at a pressure of 10 to 15 Bar to the front axle circuit of the master cylinder. The pressurized fluid also acts on the rear brake circuit of the master cylinder as well.

The Pre-charge pump ensures that an adequate amount of brake fluid is available at the hydraulic unit during brake regulation.

Teves MK60

The pre-charge pump used on previous systems is no longer required. Rapid pressure build up is possible because of the close proximity of the hydraulic unit to the master cylinder and improvements in the design of the return pump.

Tandem Brake Master Cylinder

The DSC III system uses a tandem brake master cylinder fitted with central valves as other DSC master cylinders. The central valves allow fluid to be drawn through the master cylinder during ASC and DSC regulation. The hydraulic circuit is split front/rear.

An orifice for pre-charge pressure is fitted into the brake front axle circuit and is connected to the pre-charge pump via a steel braided flexible line.

The inlet orifice is not used on the MK 60 system since the charge pump has been eliminated.

Both brake pressure sensors are mounted on the master cylinder.

Brake Fluid Expansion Tank and Brake Fluid Level Switch

The brake fluid expansion tank has internal baffles that reduce foaming during return pump operation.

The expansion tank includes a pick-up tube for clutch master cylinder fluid supply and a second lower one for the charge pump supply (not MK60).

The brake fluid level switch is incorporated into the tank on Bosch 5.7 on is incorporated into the cap on Teves systems.

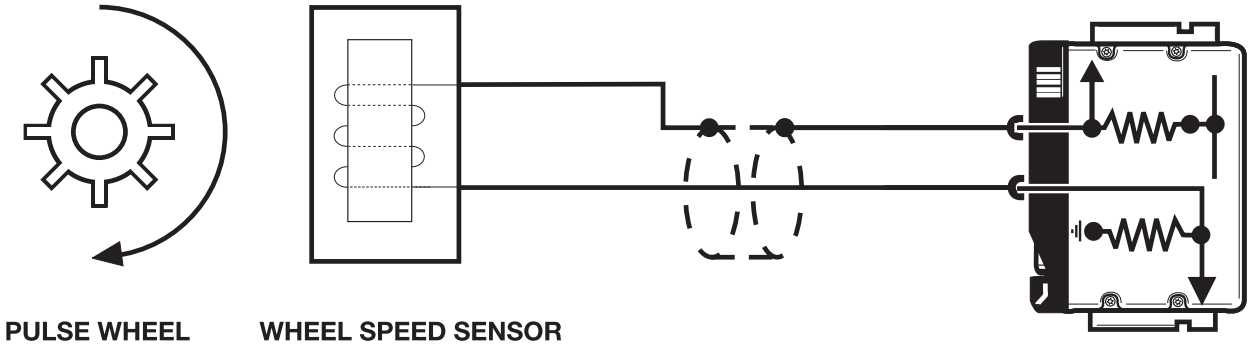
The switch is a reed contact switch. If the brake fluid is at a sufficient level, the switch is closed and switched to ground.

If the fluid level drops below a specified level , the reed contacts open and the DSC responds by switching off the ASC/DSC functions.

Normal braking and ABS operation is unaffected.

Wheel Speed Sensors (Inductive)

The E46 DSC III(Mk 20)system uses the wheel speed sensors from the ASC system. The whee speed sensors are the inductive type and generate an AC Analog Signal.



Wheel Speed Sensors (Hall Effect)

The E46/16 uses Hall-effect wheel speed sensors similar to other models with Bosch DSC III 5.7. The advantages of the Hall sensors over the inductive sensors of the Teves MK 20EI are:

- Speed signal is available from 0.3km/h.
- Signal strength is not dependent on road speed.
- The signal supplied is a digital square wave.

The pulse wheel for the front axle circuit is integrated into the wheel bearing inner seal, identical to that of E38, E39, E53, E52 models.

The pulse wheel for the rear axle circuit is identical to 2wd E46 models. The pulse wheel is a plastic coated metal wheel attached to the rear stub axle outboard C.V. Both pulse wheels produce 48 pulses:1 wheel revolution.

The color of the sensor connector is blue, just as the Magnetoresistive sensors of the Teves MK 60 used on 2wd vehicles. The front sensors of the 2wd and 4wd versions of E46 are physically different and will not fit in the wheel hub.

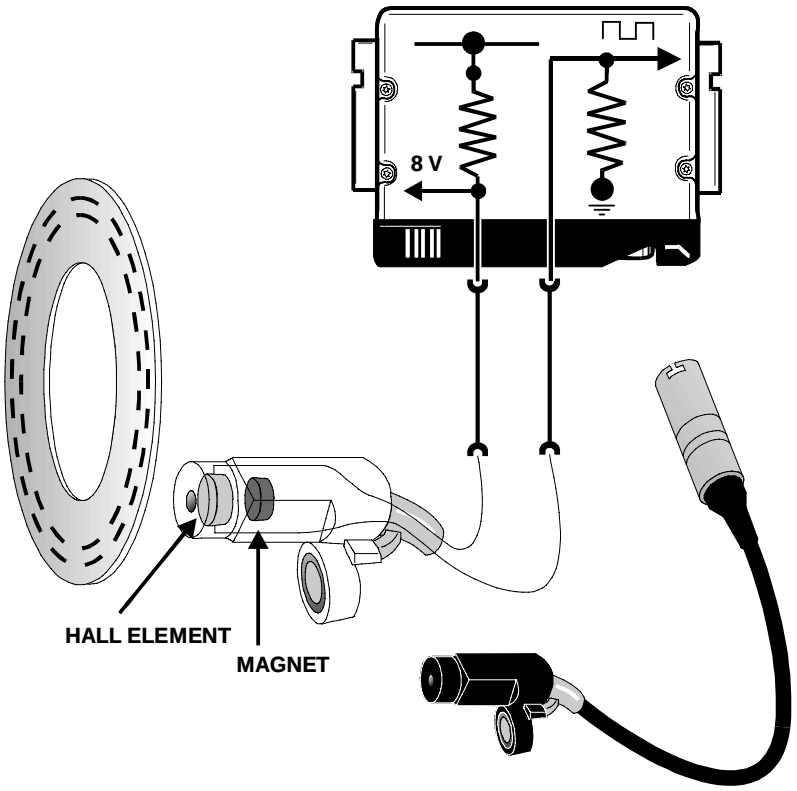
The rear sensors can be confused with the Teves MK 60 sensors and will fit in the rear axle of the 4wd car however they are not compatible with the Bosch system.

Principle of operation of the active wheel speed sensor

The sensor housing contains the evaluation circuitry, a Hall-effect transmitter and a permanent magnet. The wheel speed sensor receives a stabilized 8V operating power supply from the control unit.

Both front and rear sensors are two-wire. One wire is for the power supply, the other provides a ground for the Hall element and also provides the input signal to the control module

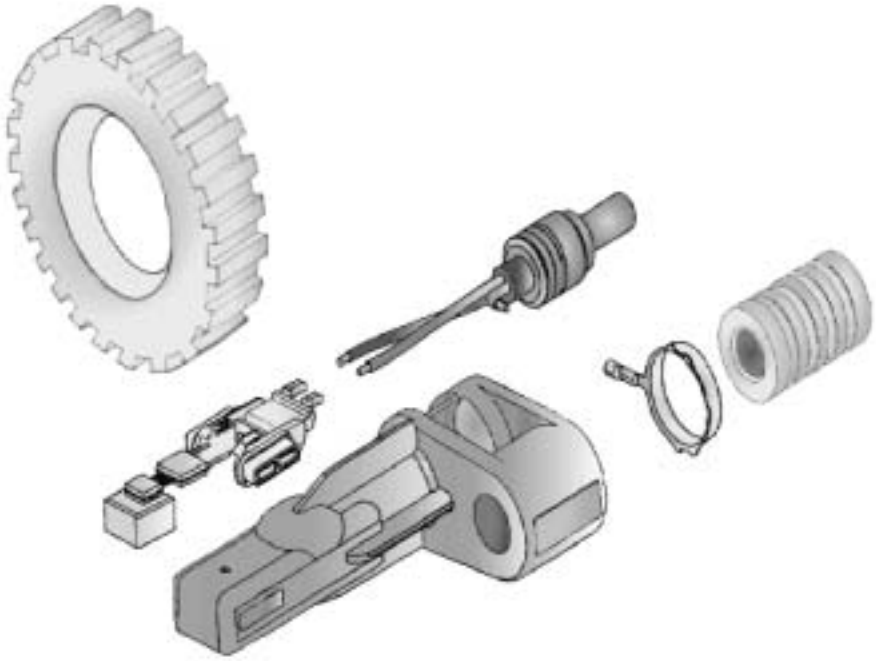
If a tooth of the pulse wheel is opposite the sensor, the signal to the DSC III is high: approx. 1.9 to 3.9 V. When opposite of the gap, the signal to the DSC III is low at 0.35 to 1.3 V.



Wheel Speed Sensors (Magneto-Resistive)

With the introduction of the Teves DSC III MK60, active wheel speed sensors that operate on the principle of magnetoresistive effect are used for the first time on BMW vehicles.

The sensor element and evaluation module are two separate components within the sensor housing.



1. **Metal pulse wheel**
2. **Magnet**
3. **Sensor element**
4. **Evaluation module**
5. **Support for sensor element**
6. **Sensor wiring with weather boot**
7. **Ground contact ring**
8. **Fastening element**
9. **Sensor housing**
10. **Pick-up surface**

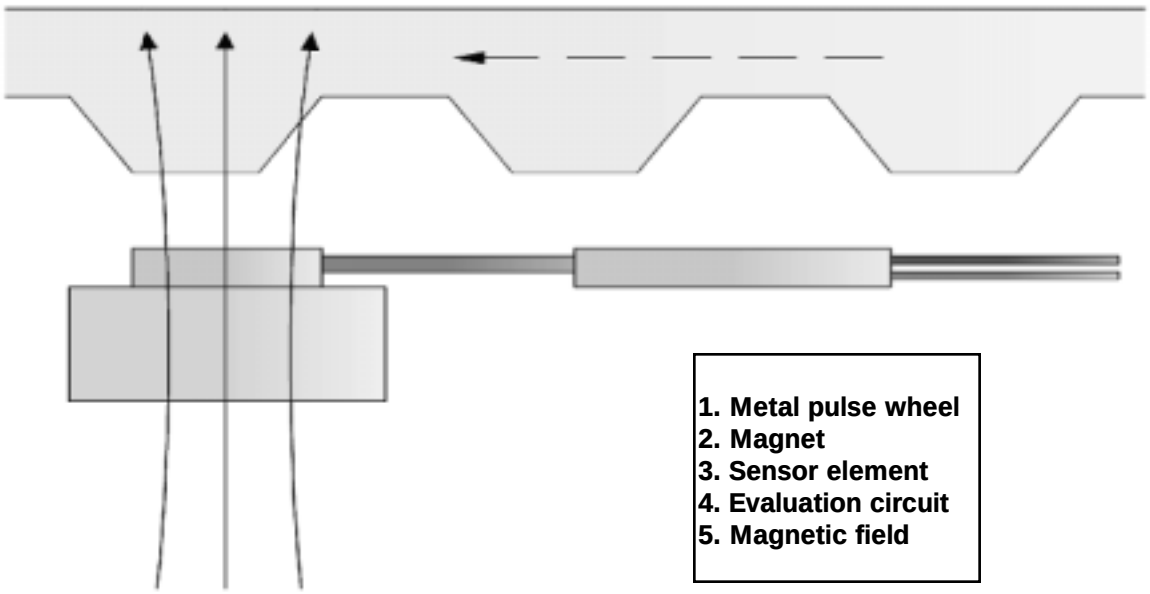
Principle of operation of the magnetoresistive sensor

The active sensing of the magnetoresistive sensor is particularly suitable for advanced stability control applications in which sensing at zero or near zero speed is required.

A permanent magnet in the sensor produces a magnetic field with the magnetic field stream at a right angle to the sensing element.

The sensor element is a ferromagnetic alloy that changes its resistance based on the influence of magnetic fields.

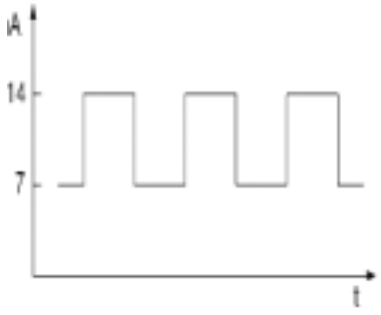
As the high portion of the pulse wheel approaches the sensing element, a deflection of the magnetic field stream is created. This causes the resistance to change in the thin film ferromagnetic layer of the sensor element.



The sensor element is affected by the direction of the magnetic field, not the field strength. The field strength is not important as long as it is above a certain level. This allows the sensor to tolerate variations in the field strength caused by age, temperature or mechanical tolerances.

The resistance change in the sensor element affects the voltage that is supplied by the evaluation circuit. The small amount of voltage provided to the sensor element is monitored and the voltage changes (1 to 100mV) are converted into current pulses by the evaluation module.

- Signal High-**14mA**
- Signal Low-**7mA**



The sensor evaluation circuit is supplied 12V by the MK60 control unit. Output voltage from the sensor is approximately 10V. The control unit counts the high and low current pulses to determine the wheel speed signal.

Front sensors are three wire because they have a separate ground wire.
Rear sensors are two wire and use the sensor case as a ground point.

Different sensors are used on the left and right side front axle of the vehicle. The difference comes in the length of the harness.

The connectors are blue to distinguish them apart from the grey connectors used for sensors on the MK20 EI.

The DSC III MK60 uses the same metal pulse wheels used with the MK20 inductive sensors.

Front Axle E46/Z3

Rear axle E46, short

Rear axle Z3

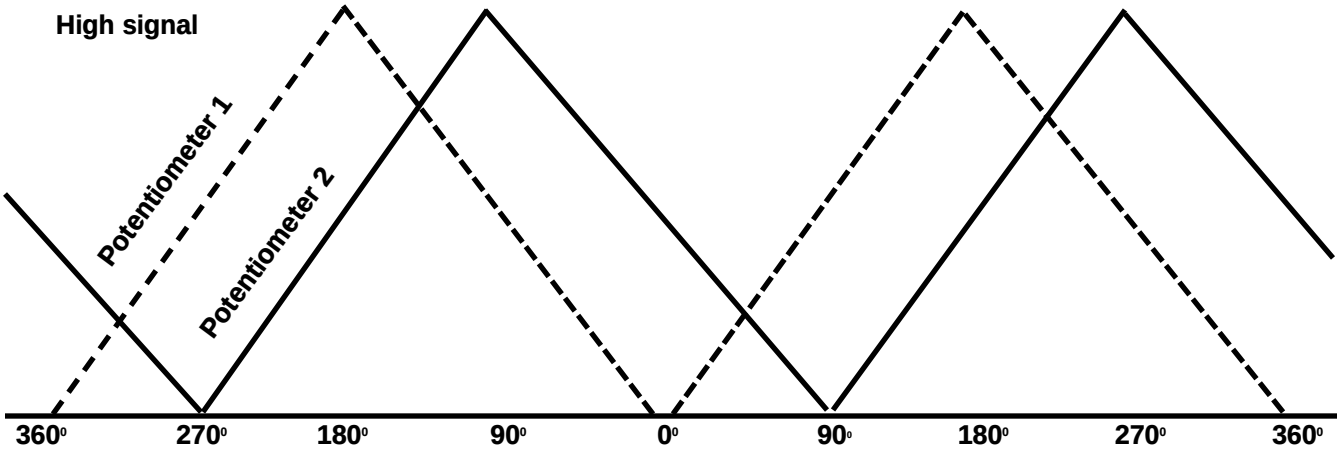
There are two types of sensors used in the rear axle of the E46:

- The short sensor is used on the 325i (any transmission) and 330i automatic.
- The long sensor is used on the 330i manual transmission version.

The Z3 uses the same sensors for the rear axle, left or right.

Steering Angle Sensor (LEW)

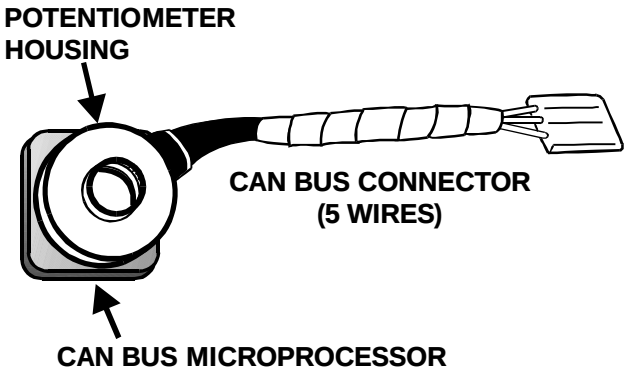
The Steering Angle Sensor is mounted towards the lower end of the steering column, above the flexible coupling. The LEW consists of a potentiometer and a built in microprocessor. The potentiometer has two pickups offset at 90° to one another. The raw potentiometer signal is processed and converted into a digital signal that is transmitted over the CAN bus to the DSC control unit.



The sensor requires initialization in-order to create a zero point default. Once initialized, the LEW sends an ID number to the DSC control unit. The ID provides confirmation that the LEW is properly initialized.

The total steering wheel angle is determined by combining the CAN telegram signal, the stored zero point default and the actual number of turns to the wheel. In order to prevent the LEW from loosing count, KL 30 is provided to the sensor and it continues to record even after the ignition has been switched off.

The DSC calculates the drivers desired rate of turn from the steering angle signal.



Pin 1. KL 30

Pin 2. KL 87

Pin 3. CAN high

Pin 4. CAN low

Pin 5. KL 31

Pin 6. TXD

Note: Refer to the Workshop Hints for instructions on coding and initializing the sensor.

Rotation Rate Sensor

The Rotation Rate Sensor is mounted on a metal bracket under the drivers seat. The sensor provides information to the DSC Control Unit concerning the vehicles speed around its main axis (yaw).

The sensor has a three pin connector with the following connections:

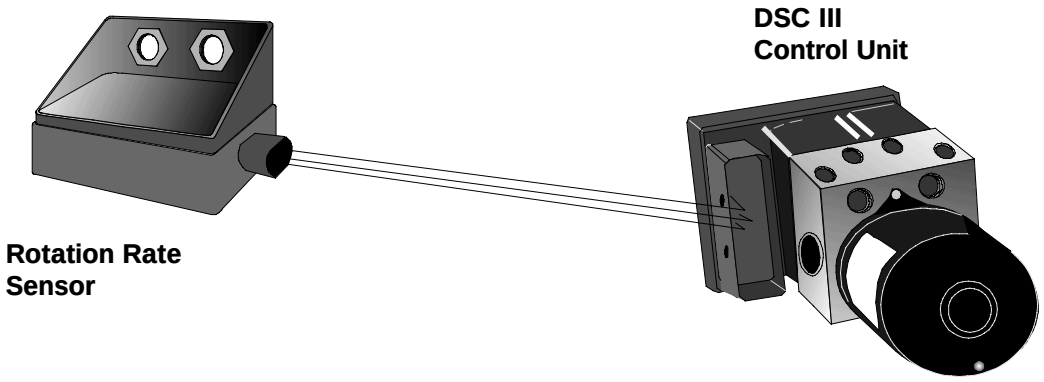
- 5V reference
- Signal
- Ground

The sensor receives a reference voltage of 5V from the MK60 control unit and provides a signal output of approximately 0.25 to 4.65V depending on the amount and direction of yaw. If the sensor is defective a constant voltage will be sent to the MK60.

The sensor element is a micro-mechanical double quartz tuning fork. A frequency of 11 Hertz is applied to one side of the fork and as the vehicle turns on it's axis, vibrations are induced on the other end.

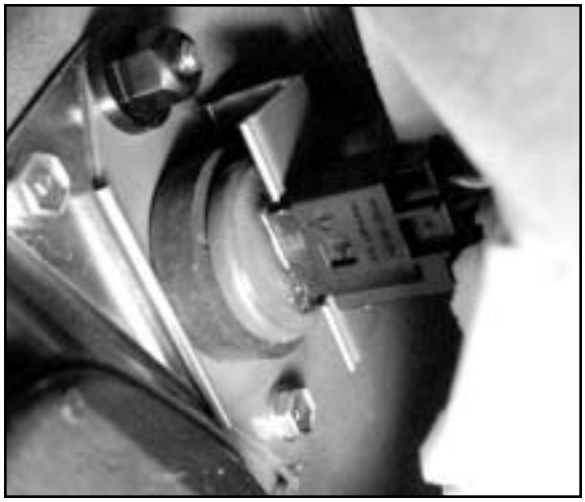
The sensor analyzes the signal produced by the fork and produces an analog voltage signal that is proportional to the amount of yaw.

The rotation (yaw) rate is compared to the signal from the Steering Angle Sensor and the Transverse Acceleration Sensor. If physical limits are beginning to be exceeded, the MK60 DSC will begin regulation by engine and brake intervention to attempt to stabilize the vehicle. This is referred to as a GMR regulation.



The MK60 DSC III for M.Y. 2002 incorporates a combined Rotation rate and Transverse Acceleration Sensor. The Sensor is connected to the MK60 control unit by the CAN bus. The Z3 version will retain separate sensors until the E36/7 is replaced by the E46/6.

Transverse (Lateral) Acceleration Sensor



The Transverse Acceleration Sensor is mounted in the left “A” pillar behind the driver’s foot rest. The sensor provides the DSC control unit with a signal that corresponds to the degree of transverse acceleration (G forces) acting on the vehicle.

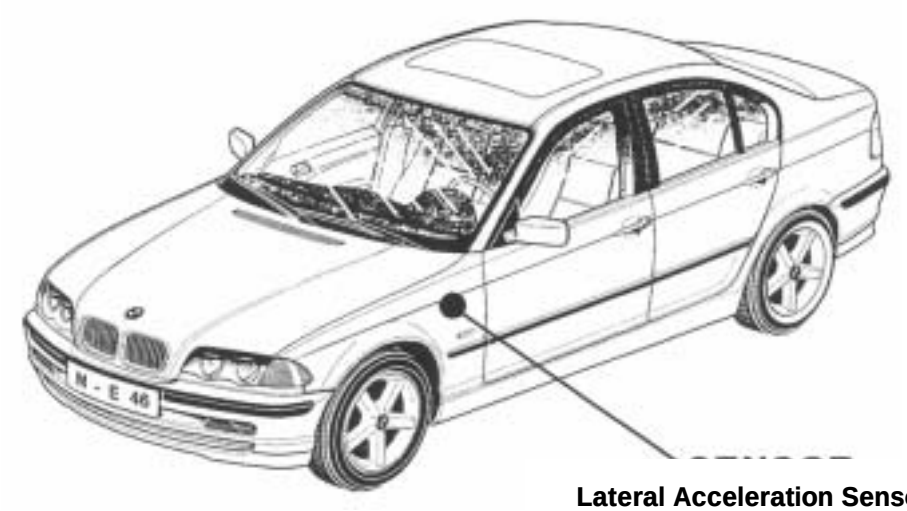
The sensor is a capacitive sensor with two plates. One plate is rigidly mounted, the other plate is mounted on a spring. Under the effect of transverse forces acting on the sensor the distance between the plates changes.

This change of distance between the plates affects the capacitance of the sensor. The evaluation circuitry converts the signal into an analog voltage that is transmitted to the control unit.

The output signal of the sensor is between the range of 0.5 to 4.5 Volts. This corresponds to -1.5 to 3.5g respectively. When the vehicle is stationary the output is 1.8V.

The transverse acceleration signal is used in the DSC III control unit along with the rotation rate and steering angle signal to determine if DSC regulation is required to maintain the vehicles stability.

Note: Refer to Workshop Hints for instructions on initializing sensor.



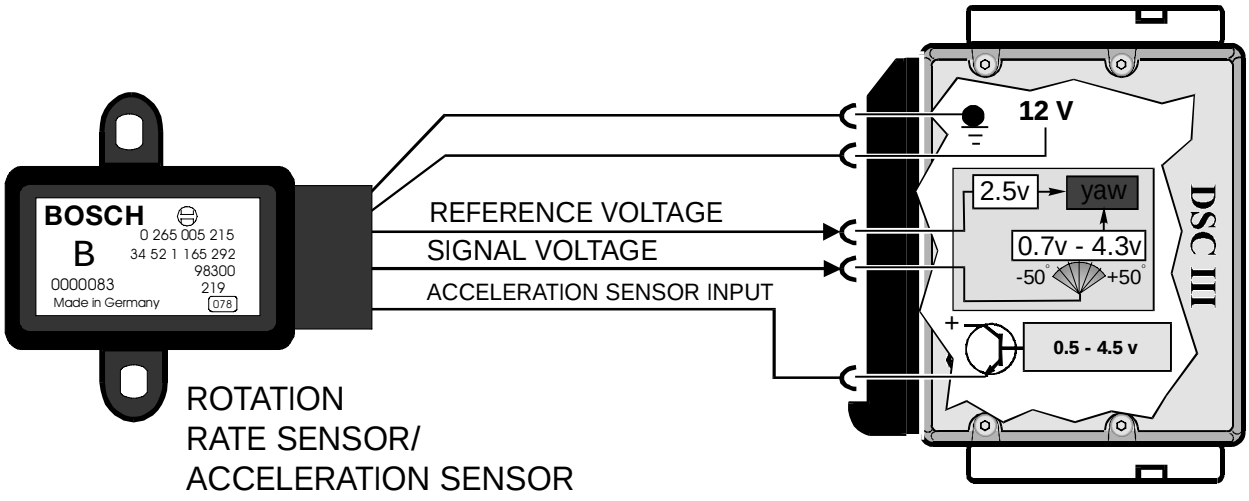
Lateral Acceleration Sensor

Integrated Rotation Rate and Transverse Acceleration Sensor

The E46/16 uses the combined rotation rate /transverse acceleration sensor used in all Bosch DSC III 5.7 systems. The sensor is located under the drivers seat in front of the left seat rail and is attached to a plate with a rubber mounting to isolate it from vibrations.

For rotational speed, the sensor produces a reference signal of 2.5 volts and a voltage input signal from 0.7 to 4.3 volts. This signal represents the rotational movement (yaw) of the vehicle from the neutral straight ahead position.

The sensor also integrates the transverse acceleration signal (side-ways acceleration). The signal range is 0.5V increasing to 4.5V as side forces (g-force) increase. This signal is combined with the rotation signal to determine when to start DSC regulation.

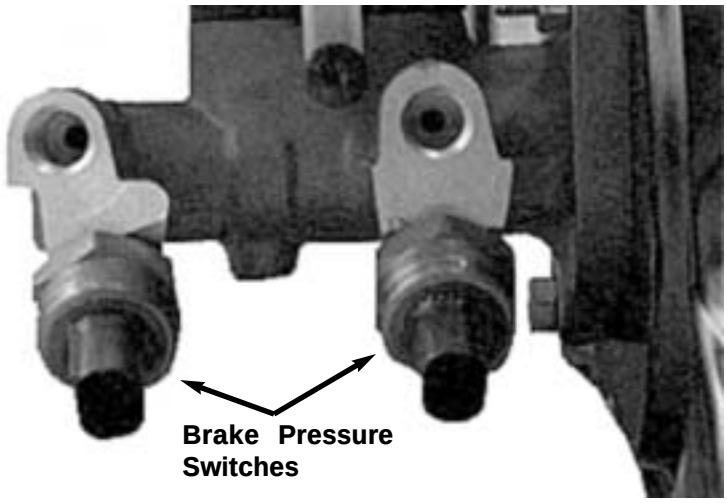


Note: Adjustment of sensors is conducted separately in Service Functions of the Diagnosis Program even though both sensors are contained in one housing.

Brake Pressure Sensors (Teves MK 20 and MK 60)

Two brake pressure sensors are mounted on the master cylinder below the outlet ports for the front and rear brake circuits. The sensors are provided a 5V reference voltage by the MK 60 control unit.

The sensor provides the control unit with an analog signal proportional to brake pressure. Voltage increases with increasing brake pressure.



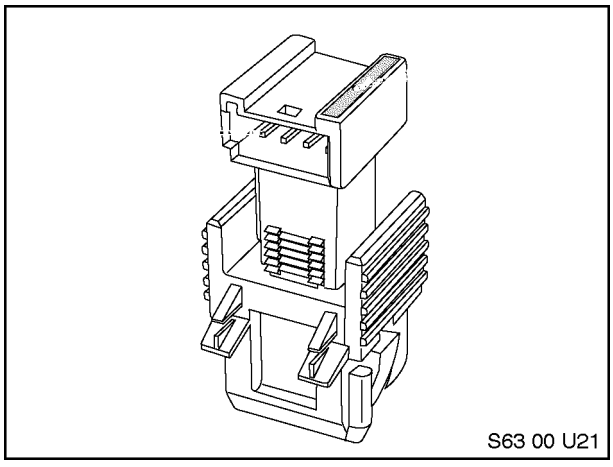
Plausibility with BLS

The signal input from the brake light switch is compared with the pressure sensor values. The pressure sensors must not detect more that 5 bar when the BLS is not actuated. Both signals are used to form a redundant BLS input which is constantly monitored.

Note: Refer to the Workshop Hints for instructions on initializing the brake pressure sensors.

Brake Light Switch (BLS)

The brake switch is an input to the MK 60 to inform it that the brakes are being applied. If the signal is received during an ASC regulation then brake regulation is interrupted.



Brake Pressure Sensor (Bosch 5.7)

The brake pressure sensor is mounted on the DSC hydraulic unit in the front axle circuit. The sensor is provided with a 5V reference voltage by the DSC control unit.

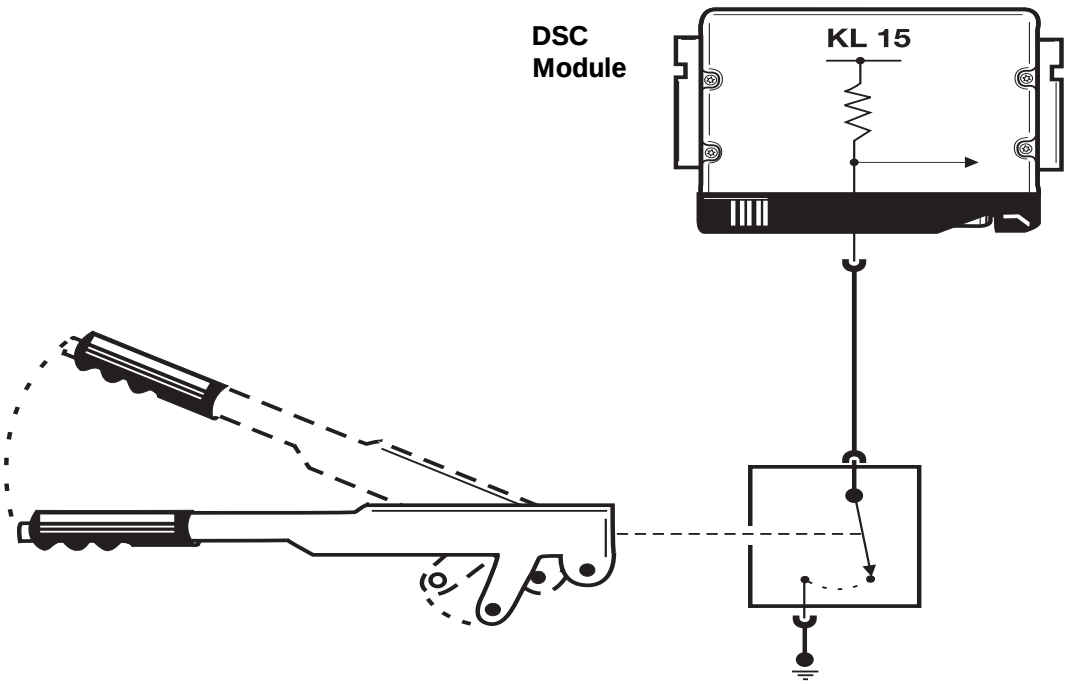
The sensor provides the control unit with an analog signal proportional to brake pressure. Voltage increases with increasing brake pressure.

Plausibility with BLS

The signal input from the brake light switch is compared with the pressure sensor value. The pressure sensor must not detect more that 5 bar when the BLS is not actuated. Both signals are used to form a redundant BLS input which is monitored during all phases

Handbrake Switch

The Hand Brake Switch is a ground input to the DSC module. This DSC module will discontinue MSR regulation when the signal is present.



DSC Button

The DSC button on the Teves MK 20 system operates just as on previous systems. The DSC system is active when the ignition switch is turned on, the DSC system is de-activated when the button is pressed. The DSC warning light will be illuminated when the system is off. The activate the system, press the DSC button again to restore operation.

DSC Button (Teves MK60)

The DSC button is located on the SZM, however the SZM provides no processing, it is simply a housing for the button which is hardwired to the MK60 control unit.

The DSC Button features two functions that can be set by varying the time the button is held down for:

Button activation	Function	Display
Short press <2.5s	Only the yaw control of the DSC is deactivated. The ADB and DBC functions remain active. A higher slip ratio is allowed up to 42 mph for the purpose of improving traction in slippery conditions. ASC uses different thresholds.	DSC light illuminated
Long press >2.5s	All ASC, ADB, DSC, GMR (yaw control) and DBC control functions are deactivated. Used for service and use on dynamometers.	DSC light and general brake warning light (yellow ABL) illuminated.

Pressing the button again returns the system to normal status. It is not possible to go directly from one function to the next without first returning to normal status.

DSC Button (Bosch 5.7 on E46 AWD)

The function of the button is different than for 2wd vehicles. Brake intervention remains active for the ADB function after pressing the button to turn off the DSC. Only ASC engine intervention and DSC yaw intervention are deactivated.

The DSC warning lamp will be illuminated to remind the driver that these functions have been disabled. Pressing the button again returns the system to normal status.

Instrument Cluster Warning Indicators

Three warning indicator lamps are arranged in the instrument cluster:

- DSC lamp: Indicates fault in DSC or system disabled by the switch.
- ABS lamp: Indicates a fault in the ABS system.
- ABL“BRAKE” lamp:

This lamp is a general brake warning and illuminates two different colors.

- Red indicates low brake fluid or hand brake engaged.
- Yellow indicates DSC/ABS fault or system disabled by the switch.

The DSC and yellow ABL lamp are controlled by the DSC III control unit via the CAN bus. The ABS lamp is controlled directly by the DSC III control unit via hardwire.

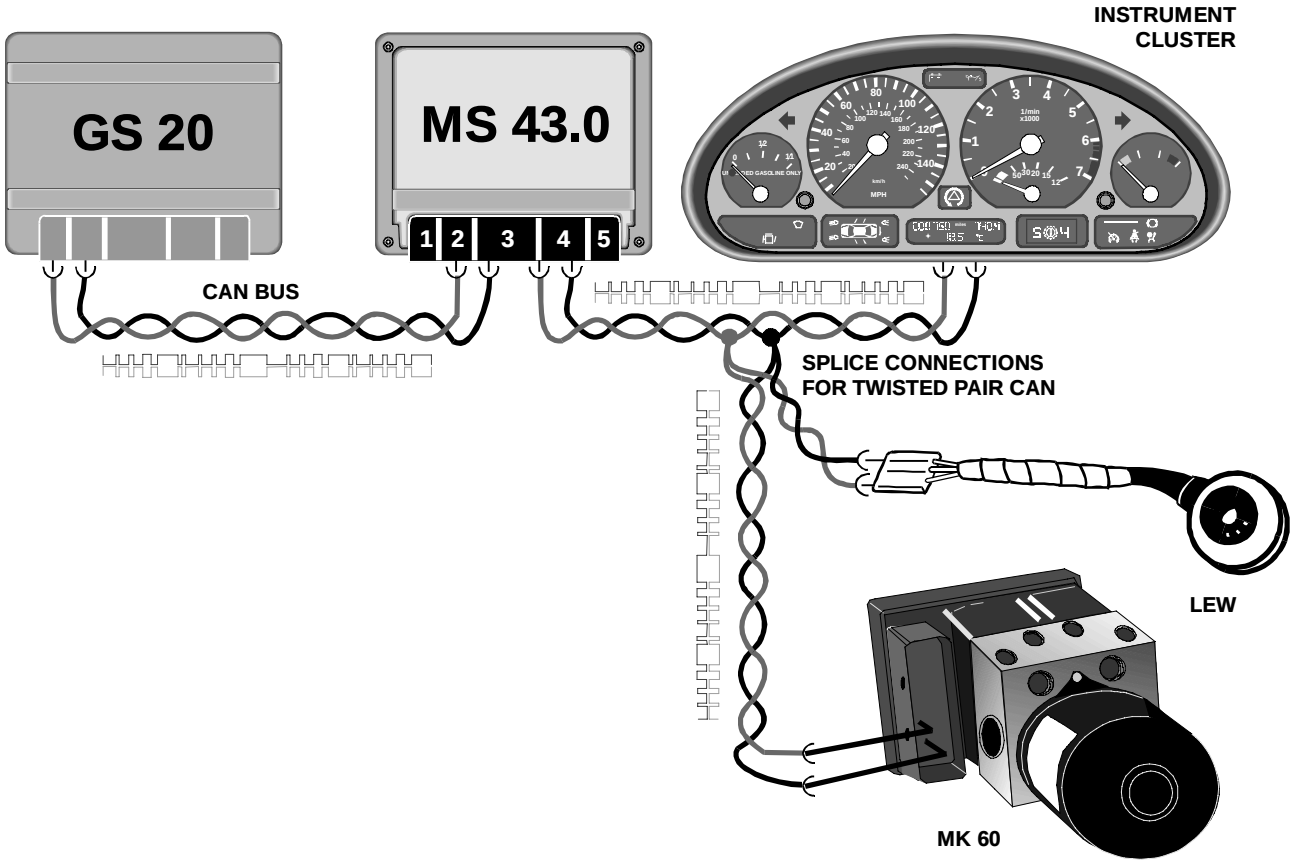
CAN Interface

The MK60 is connected to the CAN bus for communication with the AGS, DME control module, Steering Angle Sensor and the Instrument Cluster.

The CAN bus allows all of the connected control modules to send and receive information and commands.

Communication with the MK60 includes:

- **DME** - The DME sends current engine torque. MK60 commands the DME to reduce (ASC/DSC) or raise (MSR) engine torque.
- **AGS** - The MK60 commands the AGS to suppress shifts during regulation.
- **LEW** - The MK60 receives steering angle information.
- **KOMBI** - The MK60 commands the instrument cluster to activate or deactivate the warning lamps.
- All four wheels speed signals are sent over the CAN bus for use by other modules.



Principle of Operation

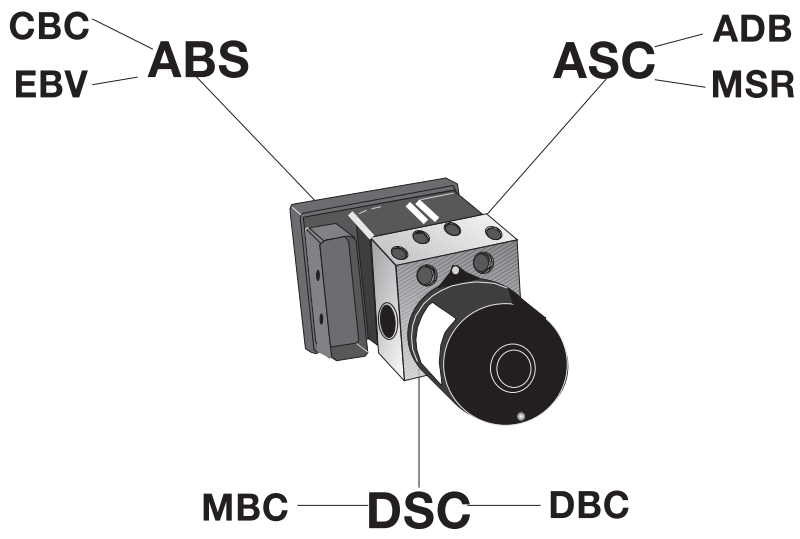
The scope of control for the DSC III is comprised of three systems:

- ABS
- ASC+T
- DSC

Based on signals coming from the various sensors the DSC III will determine which system is best suited to maintain control of the vehicle.

In addition to the three basic systems, there are several sub-functions which are activated during very specific circumstances. The sub-functions are:

- CBC
- EBV
- MSR
- ADB
- DBC
- MBC



The ABS system can prevent wheel lock when braking by comparing the four active wheel speed sensors to the average vehicle speed. If a wheel is locking during braking or has dropped below a speed threshold programmed in the control unit ABS, braking will begin. ABS braking is possible when vehicle speeds are above 12 km/h (7mph).

The function of ABS for All-Wheel Drive use has an additional variation. During braking on loose surfaces the **wedge** effect is helpful. Gravel or dirt will build up in front of the tire when the wheel is locked, creating an increased braking effect. The system allows the locking of one or both front wheels up to approx. 20km/h (12mph). This “poor road surface logic” does not affect steerability. As soon as the control unit detects steering wheel change, the ABS system regulates normally again.

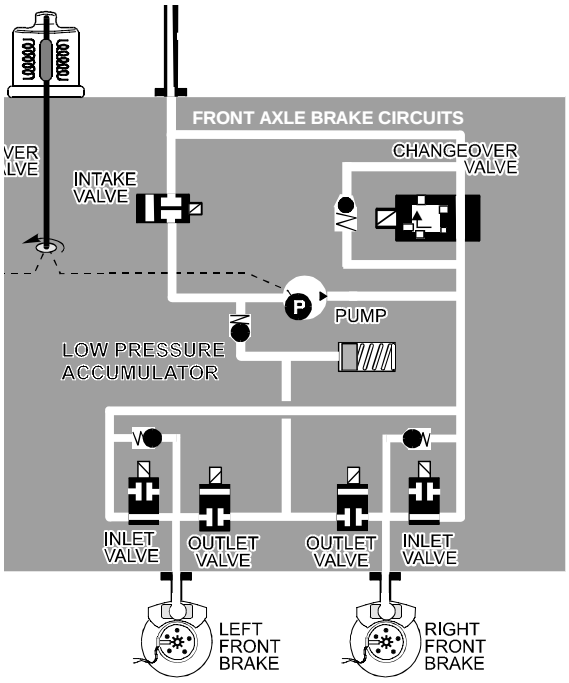
ABS regulation has three phases:

- Pressure Build
- Pressure Hold
- Pressure Release

Pressure Build already occurs during normal braking, so when ABS first intervenes it will start holding pressure by energizing the Inlet Valve. For example, if the right rear wheel is locking up, both Inlet Valves will be energized, regulating both wheels together. This logic is known as Select Low. Front wheels can be regulated individually as needed to prevent lockup.

Energizing the Inlet Valve closes the brake fluid passage to the calipers and traps the fluid at the current pressure, thus not allowing the brake pressure to rise any further.

If the wheel speed does not increase, the Pressure Release phase begins.
Pressure Release occurs when the control unit energizes the Outlet Valve while continuing



to hold the Inlet Valve closed. The trapped brake fluid is released out of the calipers reducing braking pressure.

At the same time the pump is switched on which draws in the released brake fluid and pumps it back into the pressure build-up circuit restoring the volume of brake fluid again in front of the Inlet valve.
Depending on conditions the ABS system may cycle between these three phases from 3 to 12 times a second to prevent wheel lock.

ABS Sub-functions

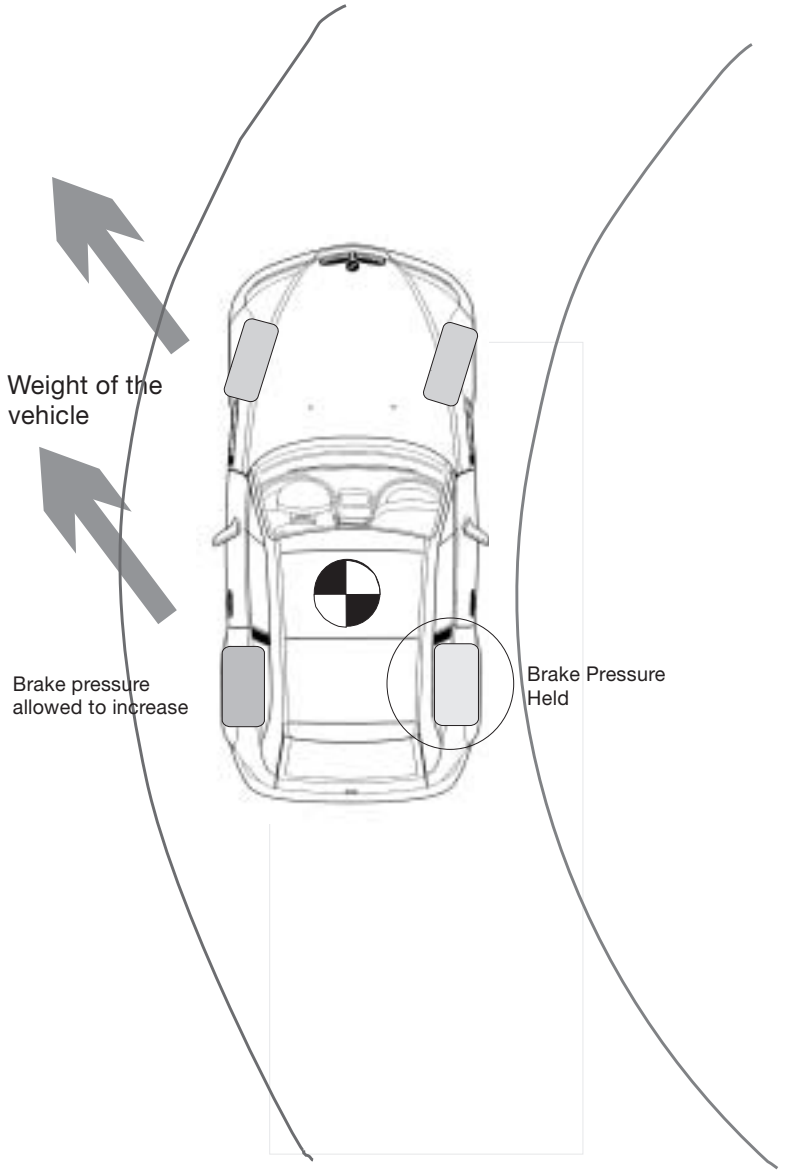
Corner Brake Control (CBC)

CBC can occur if the vehicle is cornering and ABS regulation is not taking place.

If the control unit detects transverse acceleration in excess of 0.6g and the brakes are applied, CBC prevents a build up in brake pressure to the inside rear wheel. This prevents the vehicle from entering into an unstable situation that can lead to **Oversteer**.

The DSC III accomplishes this by closing the Inlet Valve, thus not allowing brake pressure to increase at the brake caliper.

The difference in braking force between the two rear wheels creates a yaw force that opposes the oversteer and allows the vehicle to handle **neutrally**.



Electronic Brake Force Distribution (EBV)

EBV will adjust brake pressure to the rear axle based on the rate of slow-down of the rear wheels, ensuring even brake force between the front and rear of the vehicle.

The control unit monitors the wheel speed when the brakes are applied and compares the deceleration rate of the front and rear axle to determine required regulation.

If the vehicle is moderately to fully loaded, the rear axle will take longer to slow down, rear wheel brakes then can be applied at a higher pressure.

If the vehicle is lightly loaded, a similar brake pressure would be too great and result in an unstable situation.

If EBV control intervention is required, the control unit cycles the intake valve on the rear brake calipers to prevent further build-up.

Benefits of EBV are

- Enhanced braking due to an even distribution of brake force.
- Rear wheel brake size can be increased.
- Front and rear brakes wear at a similar rate.

Automatic Stability Control (ASC+T)

ASC prevents unintentional wheel slip of the drive wheels in every situation.

The DSC III control unit determines if the vehicle is loosing traction due to excessive longitudinal wheel slip based on input from the wheel speed sensors. An ASC regulating sequence is initiated if the wheel slip exceeds the control units stored allowable values.

The DSC III can control longitudinal wheel slip by two means:

- Automatic Stability Control **ASC. Engine Intervention**
- Automatic Differential Brake **ADB. Brake intervention**

ASC Engine Intervention

Engine torque may be reduced by:

- Reducing the throttle opening angle
- Retarding the ignition
- Canceling individual cylinders by fuel injection cutout.

The DSC III control unit determines the amount of torque reduction that is necessary and sends the request for regulation to the DME via the CAN bus.

ADB Brake Intervention

The ADB is an automatic differential lock that improves traction. The slipping wheel is braked by pressure built up in the hydraulic unit. The drive torque can be transferred to the wheel with the greater traction, which can transmit drive power to the road. This function acts much like a limited slip differential.

Brake intervention is applied to the individual wheel which is loosing traction by regulating the brake calipers in three phases:

- Pressure Build
- Pressure Hold
- Pressure Release

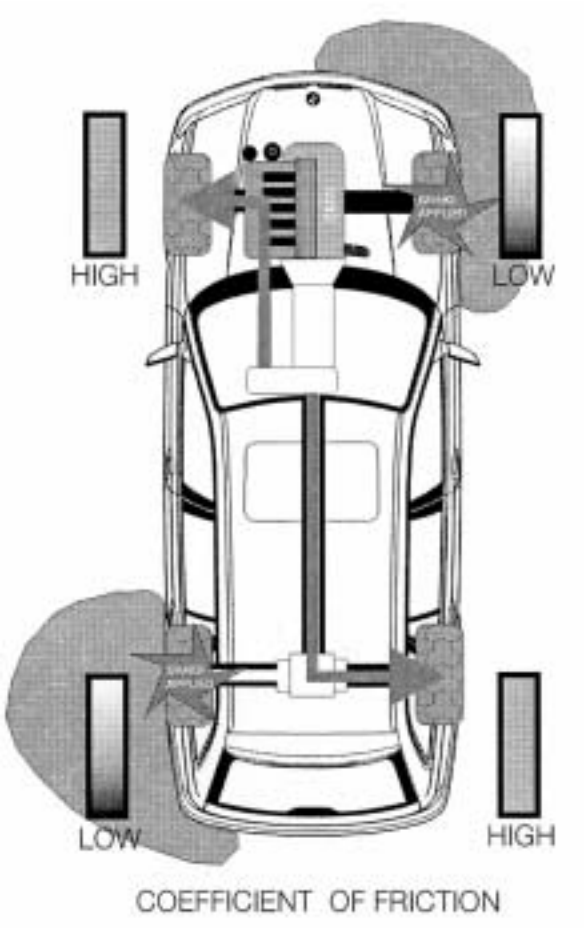
When brake intervention is necessary, the axle not being regulated must be isolated from the Pressure Build sequence in the hydraulic unit. This is accomplished by closing both Inlet Solenoid Valves for that axle.

Here is an example of an ADB brake intervention at the left rear wheel:

- The Changeover Valve for the rear brake circuit, the right rear and both front Inlet Valves are energized and closed.
- The rear brake circuit Intake Valve is energized and opened.
- The Return/Pressure pump is activated and draws brake fluid through the open Intake Valve from the Master Cylinder **(via the Central Valve)** and delivers the pressurized fluid to the open Inlet Valve braking the left rear wheel.
- Pressure Hold and Pressure Release are done by cycling the Inlet and Outlet Valves similar to the ABS sequence described previously.

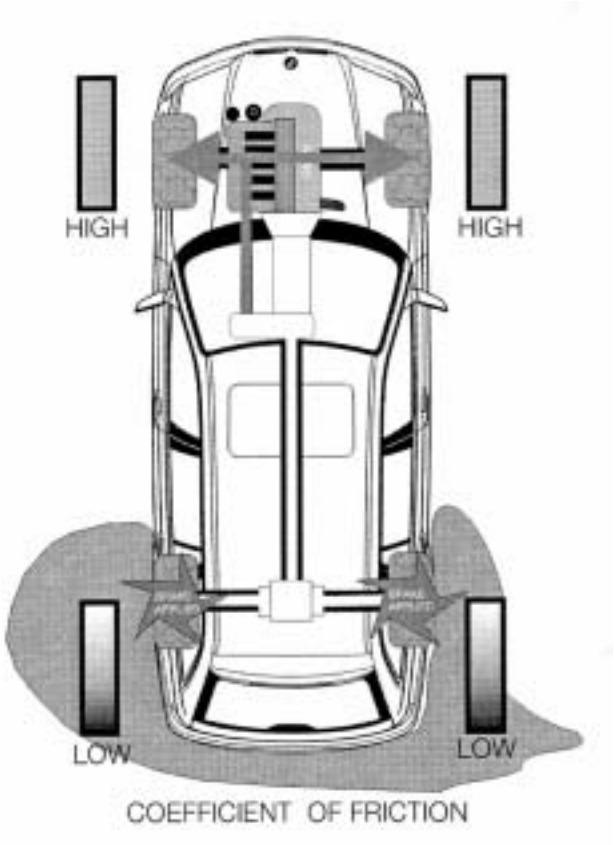
The drive torque can be distributed to the wheels with high friction coefficients (traction).

Transversal differential-lock function.



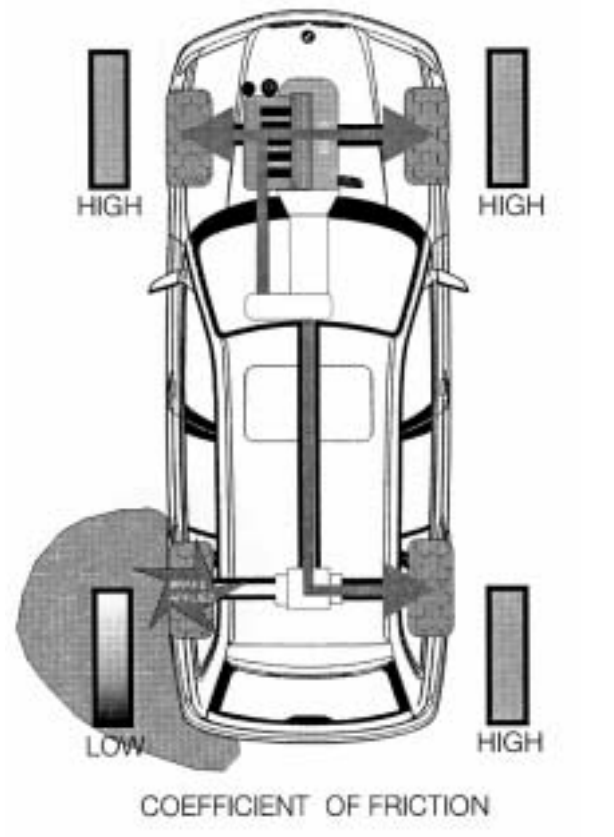
Longitudinal differential-lock function

By performing brake intervention at the axle with a low friction coefficient, drive torque can be transmitted to the front wheels.



Longitudinal and transversal differential-lock function

By performing brake intervention at the diagonally opposing wheels with a low friction coefficient, drive torque can be transmitted to the two wheels with more traction.



ASC Sub-function

Engine Drag Torque Reduction (MSR)

If the vehicle is driven in low gear when coasting down hill, or if there is a sudden shift to a lower gear, the wheels may be slowed down by the engine braking effect to rapidly. This could result in an unstable situation.

If the front wheels are turning faster than the rear wheels the DSC III control unit signals the DME via the CAN bus to **raise** the engine torque. DME cancels fuel cut-off and allows the engine speed to increase, this allows the drive wheels to accelerate to match the speed of the non-driven wheels.

MSR regulation is cancelled if the brake pedal or hand brake is applied.

Dynamic Stability Control (DSC)

With the introduction of DSC systems, lateral dynamics were taken into account for the first time. The DSC III system will initiate a DSC regulation sequence if the control unit detects a difference between the drivers desired turning angle and the actual rotation angle of the vehicle. The control unit determines vehicle stability based on:

- Steering wheel angle
- Wheel speed
- Transverse acceleration forces
- Rotation angle and speed (yaw)

Once the control unit determines that the vehicle is in an unstable situation, it also identifies whether it is oversteering or understeering. This distinction is important because it determines which control strategy should be used to help stabilize the vehicle.

DSC regulation consist of :

- Engine intervention
- Engine and brake intervention **(any wheel)**
- Brake intervention

Understeer

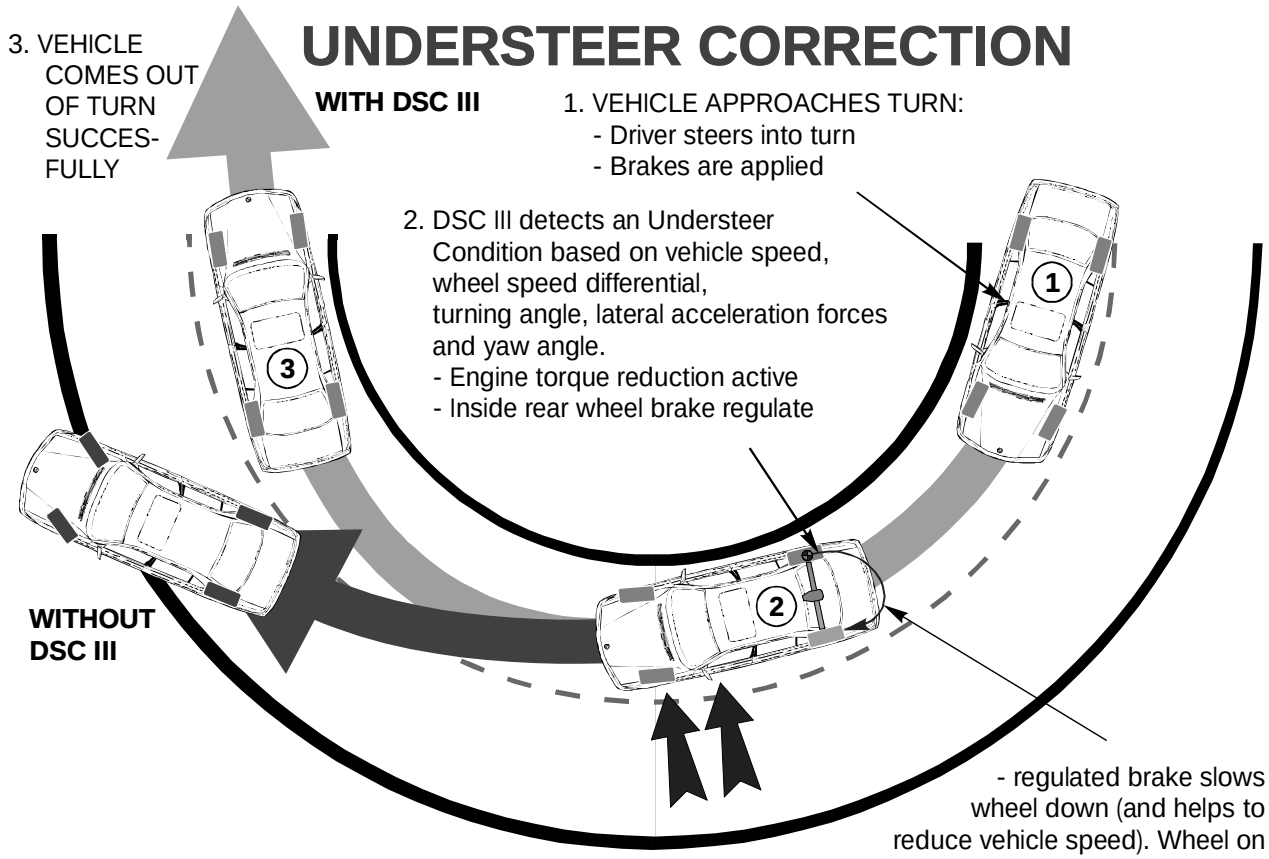
Understeer occurs when the driver wishes to turn a corner, but despite the front wheels being turned in the direction of the curve, the vehicle continues its forward track. This occurs when the front wheels no longer have sufficient lateral locating force (traction).

The DSC III can identify the situation and initiate a corrective action based on engine torque reduction followed by a controlled brake intervention sequence if needed.

Engine torque reduction is carried out by the DME from a request by the DSC via the CAN bus. The DME sends the torque reduction confirmation back to the DSC.

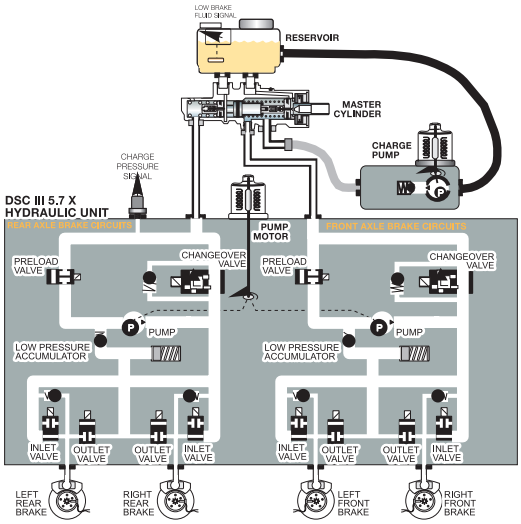
Brake intervention is carried out by the DSC III hydraulic unit if the driver is not actively braking. An example of a brake intervention at the inside rear wheel is as follows:

- All Inlet Valves are closed except for the right rear inlet.
- Intake Valve for rear circuit is opened.
- Both Changeover Valves are closed.
- Return pump operated.



Just as an ASC regulation, DSC brake intervention carries out:

- Pressure Build
- Pressure Hold
- Pressure release

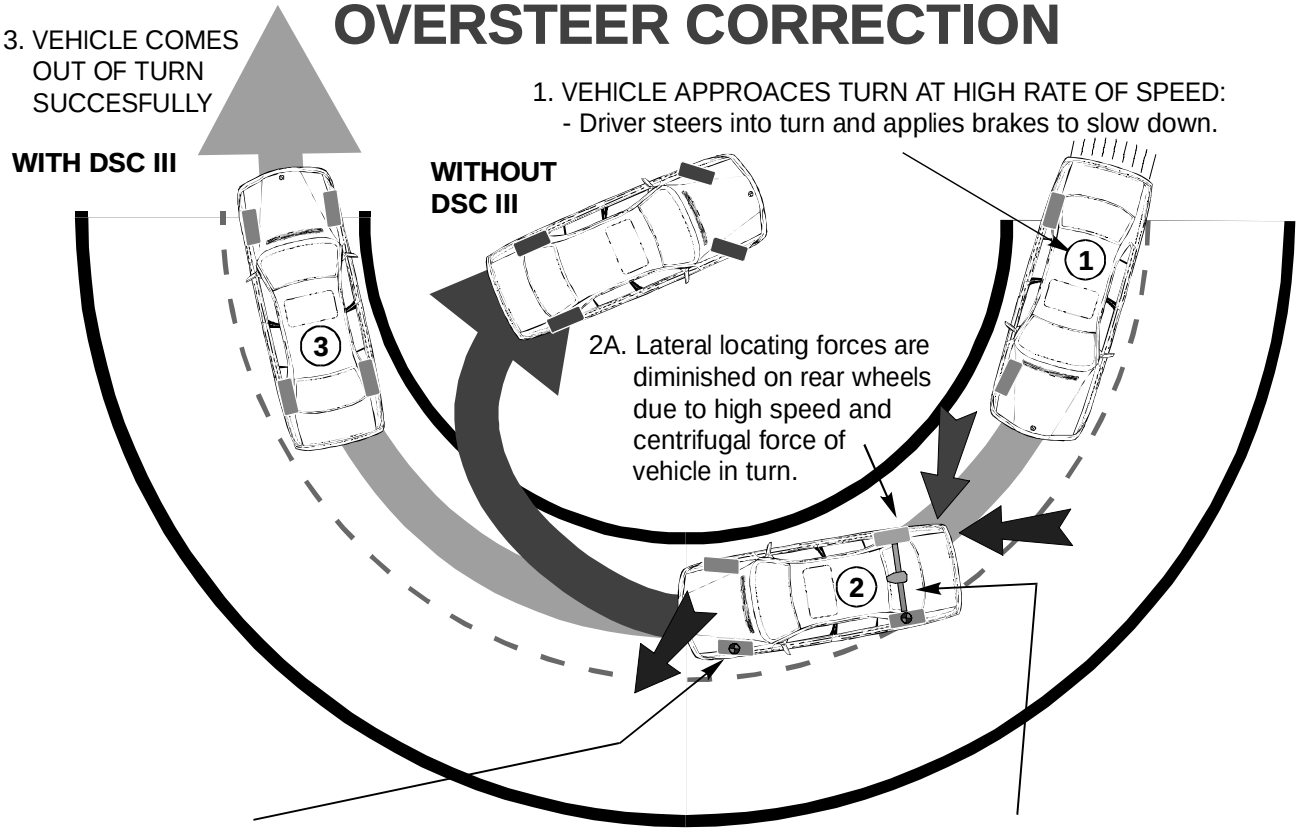


Oversteer

Oversteer occurs when the driver wishes to turn a corner and the tail of the vehicle slides outward, leading the turn. This is caused by the rear tires loosing traction and not being able to hold against the centrifugal force acting upon the vehicle.

The DSC III can identify the situation and initiate a corrective action based on engine torque reduction followed by a controlled brake intervention sequence if needed.

Engine torque reduction is carried out by the DME from a request by the DSC via the CAN bus. The DME sends the torque reduction confirmation back to the DSC.



2D. The torque reduction and rear brake regulation should stabilize the vehicle at this point. If not the left front wheel has a high degree of lateral locating force and is momentarily regulated.

This action deliberately causes the wheel to shed a calculated degree of it's locating force. This counteracts oversteer yaw at this wheel and also aids in slowing the vehicle down to correct it.

2B. Driver tries to compensate by oversteering which diminishes lateral locating force even further. Simultaneously, rear of car starts to slide out.

2C. DSC III determines an OVERSTEER condition. Engine torque is reduced via CAN Bus signalling. Outside rear wheel is momentarily regulated to counteract severe yaw angle (also helps to reduce drive torque further.)

DSC Sub-functions

Dynamic Brake System (DBS)

DBS is designed to assist the driver in emergency braking situations by automatically increasing pressure to the vehicles brake system. This allows the vehicle to stop in the shortest distance possible. DBS was first available in 1999 Bosch DSC III 5.7 systems.

The DBS system contains two functions: Dynamic Brake Control and Maximum Brake Control. DBS functions are programmed into the DSC III control unit and require no additional hardware over conventional DSC.

Dynamic Brake Control (DBC)

The DBC function is designed to provide an increase in braking pressure up to the ABS threshold during rapid (emergency) braking situations. The DSC III control unit monitors the inputs from the brake light switch and the brake pressure sensor. The triggering criteria for activation of DBC is, how rapidly is the brake pressure increasing with an application of the brake pedal. The triggering conditions are:

- Brake light switch on.
- Brake pressure in the master cylinder above threshold.
- Brake pressure build-up speed above threshold.
- Vehicle road speed above 3mph (5km/h).
- Pressure sensor self test completed and sensor not faulted.
- Vehicle traveling forward.
- Not all of the wheels in ABS regulation range.

If the threshold for DBC triggering is achieved, the DSC III control unit will activate a pressure build-up intervention by activating the pre-charge and return pump. The pressure at all wheels is increased up to the ABS regulation point. This ensures that the maximum brake force is applied to the vehicle.

During DBC the rear axle is controlled with Select-Low logic and the front wheels are regulated individually. DBC will continue until:

- The driver releases the brake pedal.
- Brake pressure falls below threshold.
- Vehicle road speed below 3mph.

DBC will also be switched off if a fault occurs in with any of the necessary input sensors. A fault in DBC will illuminate the “BRAKE” (ABL) lamp yellow to warn the driver, depending on the failure the DSC lamp may be illuminated as well.

Maximum Brake Control (MBC)

The MBC function is designed to support driver initiated braking by building up pressure in the rear brake circuit when the front wheels are already in ABS regulation.

The additional braking pressure is designed to bring the rear wheels up to the ABS regulation point shortening the stopping distance. The MBC function is triggered when the brakes are applied more slowly than the threshold needed for a DBC regulation. The triggering conditions are:

- Both front wheels in ABS regulation.
- Vehicle road speed above 3mph (5km/h).
- DBC and pressure sensor initialization test successful.
- Vehicle traveling forward.
- Rear wheels not in ABS regulation.

If the threshold for MBC triggering is achieved, the DSC III control unit will activate a pressure build-up intervention by activating the return pump. The pressure at the rear wheels is increased up to the ABS regulation point. This ensures that the maximum brake force is applied to the vehicle.

The MBC function will be switched off if:

- Front wheels drop out of ABS regulation.
- The driver releases the brake pedal.
- Brake pressure falls below threshold.
- Vehicle road speed below 3mph.

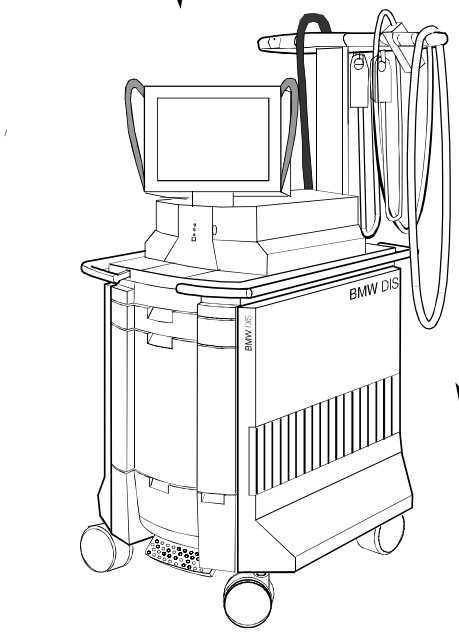
MBC will also be switched off if a fault occurs in with any of the necessary input sensors. A fault in MBC will illuminate the “BRAKE” (ABL) lamp yellow to warn the driver, depending on the failure the DSC lamp may be illuminated as well.

Diagnosis

The following diagnostic functions are available using the DISplus or GT-1.

Control Unit Functions:
Expert mode diagnosis available at any time during troubleshooting. To enter: press the Control Unit Functions button at the right lower corner of the screen.

The contents are:
- **Identification**
- **Delete Fault Memory**
- **Read Fault Memory**
- **Component Activation**
- **Status queries (requests)**



Service Functions:
Provides access to specialized test modules used as post repair procedures. To enter:
- Function Selection
- Service Functions
- Chassis
- Dynamic Stability Control

The contents are:
- **Connection Speed Sensor:** A test to verify the proper wiring to the wheel speed sensors
- **Connection Brake Lines:** A test to verify the proper brake pipe connections to the hydraulic unit.
- **Adjustment Functions:** Test modules to initialize certain components after repair work is performed
  - Steering Angle Sensor
  - Lateral Acceleration Sensor
  - Pressure Sensors

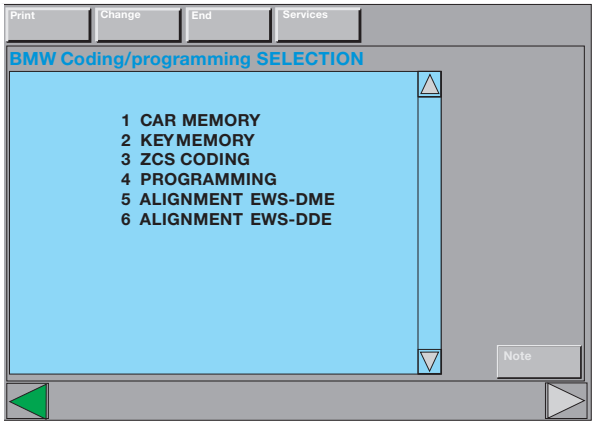
Note: E46 AWD

The all-wheel drive models of the E46 series do not have their own model identification and all-wheel drive specific equipment (i.e. DSC III 5.7) is not detected automatically. All-wheel drive identification is performed by manually selecting it from a pop-up dialog box when a document or test module is called up which has a variation for all-wheel drive.

Test Modules: Faults with the MK60 system can be diagnosed using fault or symptom driven test modules. To begin diagnosis:
- **Perform the Quick Test.**
- **Select Vehicle Symptom from the Symptom Selection page.**
- **Select Test Module from Test Plan page.**
- **Press the Test Schedule Button.**

Test Modules are configured in the E46 diagnosis concept.

Coding



Coding must be performed after replacement of the DSC III control module or the steering angle sensor. ZCS coding is found in the Coding and Programming selection from the start screen or when pressing the Change button. Follow on-screen instructions for initialization of components after completing the coding process.

Adjustment Functions

Adjustment (initialization) is required when:

- Replacing the DSC III Control Unit.
- Replacing/Re-coding the Steering Angle Sensor.
- Replacing one or both Brake Pressure Sensors.
- Replacing Lateral Acceleration Sensor.

Steering Angle Sensor

The steering angle sensor requires an offset adjustment after the sensor has been replaced, coded or after repairs to the steering or suspension system. The offset adjustment informs the steering angle sensor processor of the straight ahead position of the front wheels.

The adjustment is performed by completing the Test Module found in Service Functions. Once the adjustment is complete the sensor sends an identification number over the CAN bus to the DSC control unit. The ID provides confirmation that the steering angle sensor is coded and has successfully completed the adjustment procedure.

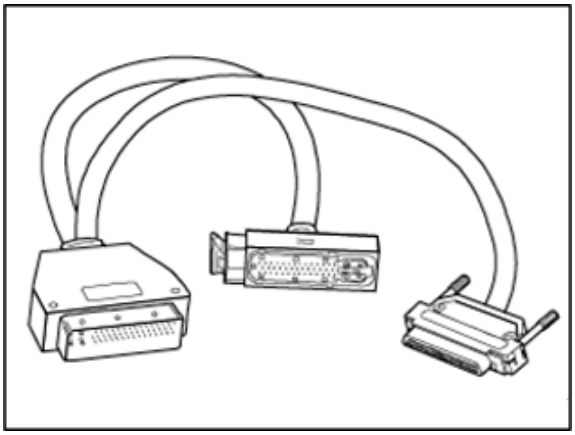
Special Tools

Special Tools available for the DSC III system consist of:

47 Pin V-Cable 34 5 250 (MK 60)

42 Pin V-Cable 34 5 240

60 Pin Break-Out-Box



review Questions

1. How does the MK20 EI ASC system communicate with DME to reduce engine power during an intervention?

2. Which component in the DSC III MK20 system is used to build-up pressure in the front axle circuit during DSC intervention?

3. What type of sensors are used in the MK20 ASC and DSC systems?

4. What is the difference in ABS control logic for the E46/16 in comparison to the 2wd models?

5. What service procedures are required when replacing a steering angle sensor?

5. What is the effect to the Bosch DSC III when the system is disabled by the DSC button? What about the button operation in the Teves MK60?

6. Describe the operation of the “Automatic Differential Lock” function.

Review Questions

7. Why is a pre-charge pump not required in the MK60 system?

8. What is the purpose of the two sensors on the MK20 and MK60 DSC III master cylinder and what is their relationship with the BLS (Brake light switch)?

9. What is the difference of the signal produced by the magneto-resistive and a Hall-effect wheel sensor?

10. List the various sensors used to detect oversteer/understeer in the DSC III systems.

11. What is the purpose of the DBS sub-function?